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Pseudostomella dolichopoda Todaro, 2012 and *P. cataphracta* Ruppert, 1970 (Gastrotricha: Thaumastodermatidae): new records from Brazil and USA and an updated key to the genus

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Abstract: *Pseudostomella dolichopoda* was originally described from the north coast of São Paulo, Brazil, and *P. cataphracta* from North Carolina, USA. Herein we report new distributional records of both species: *P. dolichopoda* is recorded from Espírito Santo, Brazil and *P. cataphracta* from Florida, USA. An updated identification key for the genus *Pseudostomella* is also provided.

Key words: Macrodasyida; Atlantic Ocean; Brazilian southeast coast; USA east coast

The genus *Pseudostomella* was erected by Swedmark (1956) to include species of Gastrotricha with a large preoral apparatus that resembles a mouth, hence the Latin etymology of the genus translates to "false mouth." *Pseudostomella* belongs to the Thaumastodermatidae, the most speciose family within the order Macrodasyida (Todaro et al. 2011). Presently, *Pseudostomella* is composed of 17 formally described species of marine macrodasyidans with a world-wide distribution (Todaro et al. 2015) (Figure 1).

The first described species was *P. roscovita* Swedmark 1956 from Roscoff, France (Swedmark 1956). While numerous species have been described and recorded from across the globe, published distributional records of the genus in both North and South America are generally lacking. In North America, three species of *Pseudostomella* were found by Ruppert (1970) in North Carolina: *Pseudostomella plumosa* Ruppert 1970, *P. cataphracta* Ruppert 1970, and *P. roscovita*. Subsequently, *P. roscovita* and *P. plumosa* have been found along the coastlines of several states and are probably widespread along the Atlantic coast of the USA (Todaro et al. 1995; Hummon 2010). However, *P. cataphracta* had yet to be recorded from outside its type locality. In South America, reports of the genus were entirely absent until Todaro and Rocha (2004) conducted a survey of marine gastrotrichs along the north coast of São Paulo state and the south coast of Rio de Janeiro state. Todaro and Rocha (2005) found a species of *Pseudostomella* that remained undescribed until 2012 when it was named *P. dolichopoda* Todaro, 2012. In 2014, Araújo et al. (2014) described a second species from Brazil, *P. squamalongispinosa* Araújo, Balsamo & Garraffoni 2014, which was collected on the northeast coast (Bahia state) of Brazil.

Studies of marine gastrotrichs have increased in the past decade with greater attention given to new geographic locations (e.g., Hochberg et al. 2013; Todaro et al. 2014; Kieneke et al. 2015; Garraffoni et al. 2016). In some cases, there is evidence for a more extensive distribution of described species than previously noted (Kieneke et al. 2013), while in others, the range might be questionable due to misidentification or the existence of cryptic species complexes (Todaro et al. 1996; Leasi and Todaro 2009; Kieneke et al. 2012). In this study, we expand the ranges of two species of *Pseudostomella* in the USA and Brazil based on metric and meristic data, and provide an updated key to the genus to assist in future identifications from new locations.

Sandy sediments containing *P. dolichopoda* were collected using a corer from the sublittoral (1 m depth) on 6 October 2014 at Praia Grande beach (20°02′25.5″ S,

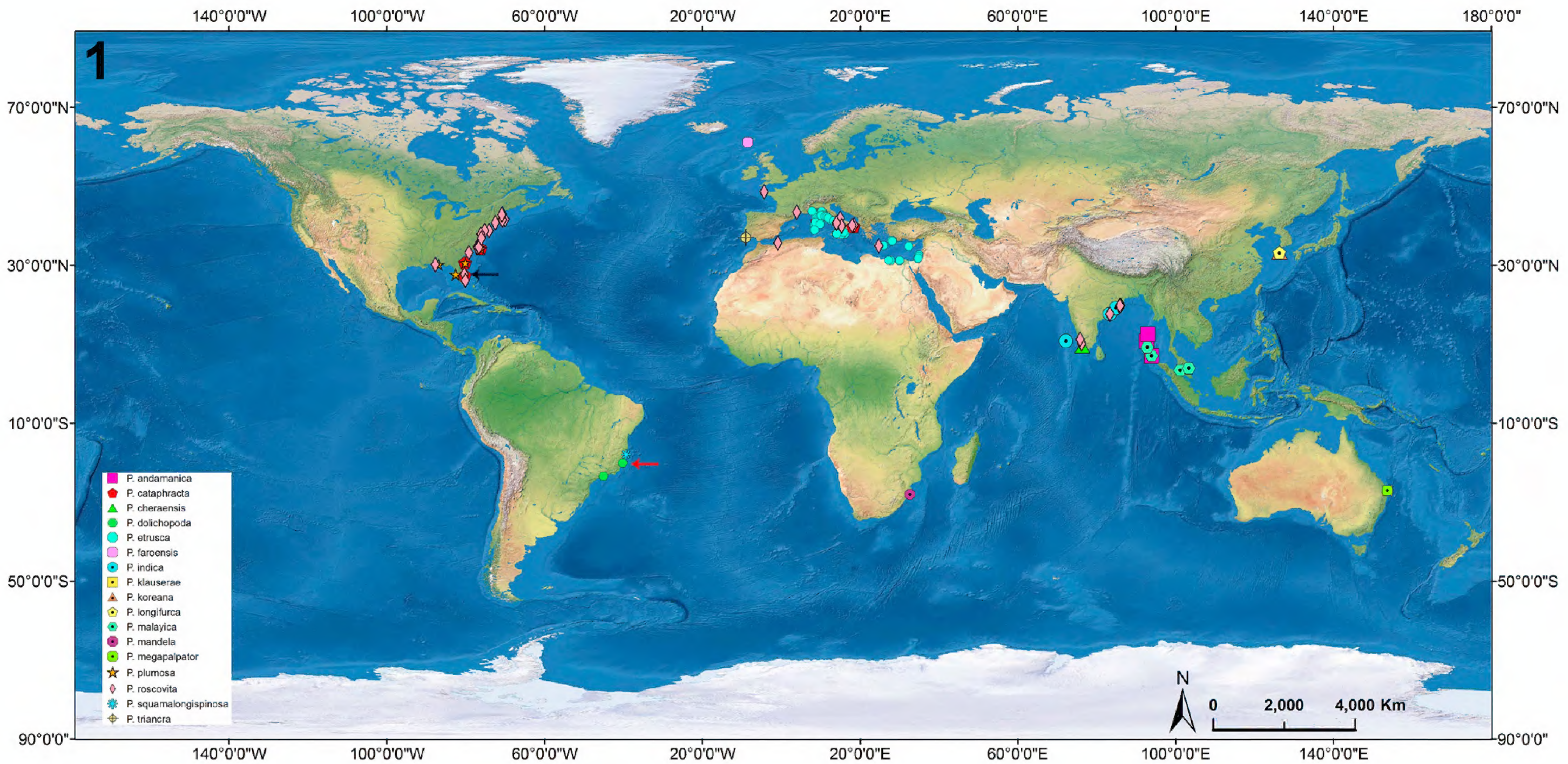

Figure 1. World map showing the distribution of *Pseudostomella* species. Black arrow indicates the new report of *P. cataphracta* and red arrow indicates the new report of *P. dolichopoda*.

040°11′00.6″W), municipality of Fundão, southern coast of the state of Espírito Santo, Brazil. A photo of a *P. dolichopoda* specimen is deposited at the Museu de Zoologia, Universidade Estadual de Campinas, Brazil, under accession number 29. Sandy sediments containing *P. cataphracta* were collected on 14 July 2015 from an offshore site, approximately 7 km east of the Fort Pierce Inlet, Florida, USA. The Smithsonian Marine Station's R/V Sunburst was used to drag a small anchor dredge (29×12-cm opening) at approximately 12 m depth (dredge in: 27°28.79′N, 080°13.69′W; dredge out: 27°29.08′N, 080°13.76′W) for 15 min. A video of a *P. cataphracta* specimen is deposited at the Museu de Zoologia, Universidade Estadual de Campinas, Brazil, under accession number 30. Extraction of sediments from Brazil and USA were performed following the protocol reported by Hochberg and Atherton (2010). In both cases samples were placed into buckets and in the laboratory live specimens were sorted using a Leica EZ4 stereomicroscope, mounted on glass slides in seawater/$MgCl_2$ solution, observed alive under a PrimoStar Zeiss light microscope and photographed using a Zeiss A1 compound microscope equipped with DIC and a Sony Handycam digital video camera.

The description of the species and the abbreviations used follow the convention of Hummon et al. (1992) and Hochberg and Atherton (2010), where the positions of morphological characters along the body are given in percentage units (U) of total body length as measured from the anterior to posterior end.

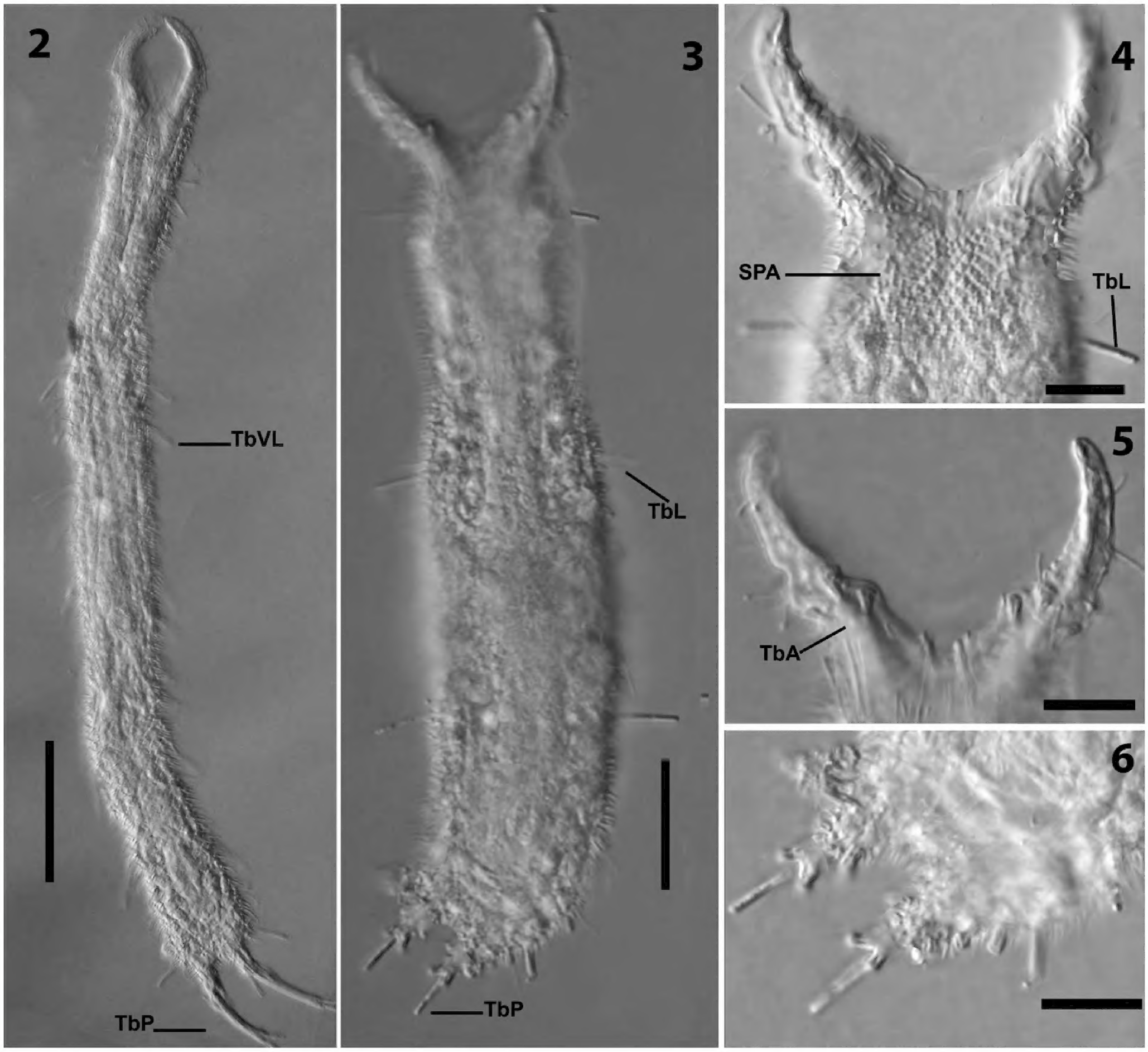

Figure 2–6. DIC photomicrographs. **2:** Ventral view of *Pseudostomella dolichopoda*. **3–6.** *Pseudostomella cataphracta*. **3.** Ventral view of body. **4.** Dorsal view of anterior part of body. **5.** Close-up of ventral view of preoral apparatus. **6.** Posterior adhesive tubes. Scale Bars: 2–3, 50 µm and 4–6, 20 µm. SPA, small pentancres area; TbA, anterior adhesive tube; TbL, lateral adhesive tube; TbVL, ventro-lateral adhesive tubes; TbP, posterior adhesive tubes.

Pseudostomella dolichopoda Todaro, 2012 (Figure 2) is 375 µm long, with a pharynx of 75 µm length, and with pharyngeal pores at its base. Pharyngeo-intestinal junction (PhIJ) at U30; body slender, elongate, with furcate caudum. Head with 37.5 µm long preoral palps, curving forward; palps possess few sensory hairs and have five and eight papillae on the dorsal and ventral borders, respectively. Thirteen sensory hairs are spaced along the lateral margin of the body. Cuticular armature is composed of pentancres on the entire dorsal and ventrolateral surfaces, except for a T-shaped bare area behind preoral palps. There are two anterior adhesive tubes (TbA) per side arranged in a row, 7 µm long at U8. One dorso-lateral adhesive tube (TbDL) per side inserts on the posterior trunk region. There are 11 ventrolateral adhesive tubes (TbVL) per side, two at the anterior pharyngeal region, seven spaced at the intestinal region, and a further two originate from a common base at end of trunk, with variable length (12–17 µm). Two long pedicles with four adhesive tubes (TbP) per side, three at the tip of each pedicle and the fourth located medially. A continuous field of transverse rows of cilia covers the entire ventral surface from U11 to U36; the field splits in the anterior intestinal region to form paired lateral columns that extend to the anal-genital area at U86.

The single damaged specimen collected in the state of Espírito Santo is slightly larger, 375 µm, than those reported by Todaro (2012), 358 µm. The specimens of the present study are morphologically identical with the original description of *P. dolichopoda* (Todaro 2012) recorded from São Paulo state.

Pseudostomella cataphracta Ruppert, 1970 (Figures 3–6) is 325 µm long, with a 100 µm long pharynx and a pharyngeo-intestinal junction (PhIJ) at U50. Body slender, elongate and with a furcate caudum. Head with 55 µm long preoral palps, curving forward; palps possess few sensory hairs and are provided with seven papillae (3+1+3) on the dorsal and ventral borders respectively. Sensory hairs are spaced along the lateral margin of the body. Cuticular armature is composed of pentancres on the entire dorsal and ventrolateral surfaces. A triangular area behind the preoral palps is covered by small pentancres (1 µm) (Figure 4). There are three anterior adhesive tubes (TbA) per side forming an arc (6, 8 and 6 µm long) at U15 (Figure 5), three pairs of lateral adhesive tubes (TbL), 24 µm long, at U21/U54/U75, and 13–14 ventrolateral adhesive tubes (TbVL) per side, 5–15 µm long. Two pedicles are present with five posterior adhesive tubes (TbP) per side (Figure 6): one medial tube (5 µm), three central tubes at the tip of each foot as two short tubes (6 µm) and one elongate tube (18 µm), and a lateral tube (5µm). A continuous field of transverse rows of cilia covers the entire ventral surface of the body.

The single specimen found in Florida is slightly larger than those reported by Ruppert (1970) (300 µm, maximum length found by Ruppert 1970). Morphologically, the specimens of the present study match the original description of *P. cataphracta* recorded from North Carolina, USA. However, the Florida specimens have longer TbL and median TbP than those described by Ruppert (1970), 15–20 µm long and 12 µm long, TbL and median TbP respectively.

As pointed out by Todaro et al. (2015), species of *Pseudostomella* appear to have a relatively restricted geographic range, as the majority of them can be found in only one biogeographic region, and sometimes only in the type locality (Figure 1; Table 1). The unique exception among *Pseudostomella* is *P. roscovita*, which appears to be a cosmopolitan species since it has been found in the Nearctic, Palearctic and Oriental biogeographic regions (Hummon 2010).

Pseudostomella dolichopoda is widespread along the north coast of São Paulo, as it was found on 10 of 24 beaches sampled by Todaro and Rocha (2004, 2005). The coasts of Rio de Janeiro (Todaro and Rocha 2005) and Bahia (Araújo et al. 2014) have also been sampled, but to date, *P. dolichopoda* has not been found there. The current record of *P. dolichopoda* in Espírito Santo state is therefore the first time that the species has been found outside São Paulo. This new record extends the range of this species 800 km northwards.

Regarding the biogeography of the two Brazilian species of *Pseudostomella* (*P. dolichopoda* and *P. squamalongispinosa*), it is important to note that the Doce river in southeastern Brazil (Espírito Santo state) could be a potential barrier to their dispersal from the north (Bahia) to the south (São Paulo and Rio de Janeiro). The Doce river has an annual average freshwater discharge of 900 $m^3 \cdot s^{-1}$ (Oliveira et al. 2012) and a sediment discharge 11.22 × 10^6 tons $year^{-1}$ (Lima et al. 2005), which is likely to disturb the benthic fauna. Until present, *P. dolichopoda* is only found south of the river outflow and *P. squamalongispinosa* only to the north.

So far, *Pseudostomella cataphracta* had a limited range in the USA as it was only found in North Carolina (Ruppert 1970; Hummon 2010) and Georgia (Hummon 2010). This new record from Florida extends the range of this species 200 km southwards. Beyond the USA, this species has also been found in shallow waters in the Mediterranean Sea (Todaro et al. 2006; Hummon 2010), which makes it another candidate for a putative cosmopolitan species of the genus.

Finally, Todaro (2012) provided a taxonomic key for all known species of *Pseudostomella* plus an unidentified species. However, subsequent publications have added two new taxa (Araujo et al. 2014; Todaro et al. 2015) for which we provide an updated and revised key.

Table 1. Coordinates of *Pseudostomella* species and authors used to build the distribution map.

Species	Latitude/Longitude	Country	References
P. etrusca	42°33′ N, 008°46′ E; 41°42′ N, 009°24′ E; 42°44′ N, 009°20′ E; 42°22′ N, 009°31′ E; 42°39′ N, 009°03′ E; 42°06′ N, 009°33′E	France	Hummon et al. 1993; Hummon 2010.
	37°58′ N, 016°07′ E; 37°50′ N, 015°17′ E; 43°09′ N, 010°40′ E; 43°09′ N, 010°40′ E; 43°44′ N, 010°16′ E; 43°44′ N, 010°16′ E; 43°48′ N, 007°46′ E; 41°31′ N, 012°32′ E; 40°17′ N, 008°29′ E; 39°07′ N, 008°21′ E; 40°55′ N, 008°43′ E; 42°49′ N, 010°44′ E; 42°39′ N, 011°04′ E; 42°39′ N, 011°01′ E; 42°21′ N, 010°54′ E; 40°52′ N, 014°01′ E; 38°25′ N, 015°51′ E; 42°27′ N, 011°09′ E; 42°43′ N, 010°08′ E; 42°27′ N, 011°09′ E; 40°26′ N, 009°50′ E; 40°54′ N, 014°02′ E; 42°20′ N, 011°33′ E; 40°25′ N, 014°58′ E; 40°44′ N, 014°00′ E; 38°02′ N, 013°58′ E; 38°02′ N, 014°04′ E; 42°02′ N, 011°56′ E; 41°17′ N, 013°15′ E; 38°58′ N, 008°26′E	Italy	
	34°50′ N, 032°21′ E	Cyprus	
	31°14′ N, 029°58′ E; 31°16′ N, 027°49′ E; 31°12′ N, 029°56′ E; 31°17′ N, 030°01′ E; 31°20′ N, 027°14′ E	Egypt	
	36°23′ N, 028°10′ E; 35°02′ N, 025°57′ E; 36°21′ N, 027°57′ E; 36°12′ N, 028°09′E	Greece	
	31°40′ N, 034°34′ E; 32°43′ N, 034°56′ E; 32°19′ N, 034°51′ E; 31°53′ N, 034°41′E	Israel	
P. andamanica	07º03′34.2″ N, 093°054′49.399″ E; 10°46′0.001″ N, 092°37′0.001″ E; 12°34′42.301″ N, 092°57′43.801″ E	India	Rao 1993
P. cheraensis	12°97′ N, 077°56′ E	India	Pryialakshmi Menon and Todaro 2007
P. faroensis	61°13′ N, 008°29′ W	Faroe Islands, Denmark	Clausen 2004
P. klauserae	27°01′ S, 153°35′ E	Australia	Hochberg 2002
P. megapalpator	27°01′ S, 153°35′ E	Australia	Hochberg 2002
P. plumosa	34°18′00″ N, 076°13′10″ W; 34°41′ N, 076°40′W; 34°40′ N, 076°40′ W; 30°42′ N, 080°11′ W; 34°18′ N, 076°13′ W; 27°45′ N, 082°35′ W; 27°46′ N, 082°35′ W; 41°45′ N, 070°26′W; 30°16′ N, 086°55′ W	United States of America	Ruppert 1970; Hummon 2010.
P. mandela	28°07′18″ S, 032°33′43″ W	South Africa	Todaro et al. 2015
P. squamalongispinosa	17°54′ S, 039°22′ W	Brazil	Araújo et al. 2014
P. triancra	37°01′ N, 008°57′ W	Portugal	Hummon 2008
P. koreana	33°14′13″ N, 126°19′23″ E	South Korea	Lee and Chang 2002
P. longifurca	33°14′13″ N, 126°19′23″ E	South Korea	Lee and Chang 2002
P. malayica	07°03′34.2″ N, 093°54′49.399″ E; 009°12′ N, 092°50′ E	India	Naidu and Rao 2004;
	03°54′ N, 103°22′ E; 03°25′17.299″ N, 101°09′01.598″ E	Malaysia	Renaud-Mornant 1967; Hummon 2010
P. dolichopoda	23°23′04.4″ S, 045°03′49.9″ W; 20°02′25.5″ S, 040°11′00.6″ W	Brazil	Todaro 2012; Current study
P. indica	17°43′30″ N, 083°20′30″ E; 19°14′23.5″ N, 084°53′18.1″ E; 10°50′37.5″ N, 072°11′07.699″ E	India	Rao 1970; Naidu and Rao 2004
P. cataphracta	39°50′38″ N, 018°23′11″ E; 39°50′ N, 018°13′ E; 41°12′ N, 009°09′ E	Italy	Todaro et al. 2006; Hummon 2010
	27°28′08.9″ N, 080°12′30.4″ W; 34°18′00′′ N, 076°13′10″ W; 30°42′ N, 080°11′ W; 34°18′ N, 076°13′ W	United States of America	Ruppert 1970; Hummon 2010; Current study.
P. roscovita	35°42′ N, 000°52′ W	Algeria	Hummon 2010
	43°31′ N, 003°57′ E; 48°38′51.5″ N, 004°18′47.1″ W	France	Swedmark 1956; Hummon 2010
	40°12′ N, 018°26′ E; 42°00′ N, 014°59′ E; 40°09′ N, 017°57′ E; 40°44′ N, 013°55′ E; 40°00′ N, 015°21′ E; 40°45′ N, 013°56′ E; 40°00′ N, 015°15′ E; 40°44′ N, 014°00′ E	Italy	Hummon 2010
	34°59′ N, 024°45′ E; 30°14′ N, 087°44′ W;	Greece	Hummon 2010
	38°47′ N, 074°06′ W; 38°47′ N, 075°09′ W; 27°44′ N, 080°22′ W; 26°13′ N, 080°05′ W; 41°32′ N, 070°41′ W; 43°00′ N, 070°40′ W; 41°32′ N, 070°41′ W; 41°40′ N, 070°00′ W; 41°31′ N, 070°40′ W; 41°33′ N, 070°40′ W; 43°00′ N, 070°40′ W; 34°38′ N, 077°05′ W; 34°43′ N, 076°45′ W; 34°41′ N, 076°40′ W; 34°41′ N, 076°39′ W; 42°53′ N, 070°49′ W; 40°50′ N, 072°30′ W; 33°17′ N, 079°12′ W; 37°54′ N, 076°07′ W; 36°55′ N, 076°03′ W	United States of America	Hummon 2010
	10°08′ N, 076°08′ E; 17°42′ N, 083°18′ E; 19°51′ N, 086°03′ E; 19°52′ N, 086°07′ E; 17°41′ N, 083°17′ E; 17°43′ N, 083°20′ E; 19°46′ N, 805°46′ E; 19°47′ N, 085°49′ E; 19°48′ N, 085°51′ E; 11°15′30.7″ N, 075°46′06.9″ E	India	Hummon 2010; Naidu and Rao 2004

1a Cuticular armature of triancres (straight, curved or feathered tines) 2
1b Cuticular armature of tetrancres (straight, curved or feathered tines) or pentancres 6

2a Feathered tines only; five dorsal papillae (1+3+1) on the prebuccal apparatus 3
2b Prebuccal apparatus with seven papillae (2+3+2) ...4

3a Medial papillae longer than lateral papillae; four TbA per side; bilateral foot-like TbV present (3 tubes per side) .... *P. megapalpator* Hochberg, 2002
3b Papillae of roughly equal size; five TbA per side; foot-like TbV absent ... *P. klauserae* Hochberg, 2002

4a Feathered triancres; all tines arise from a common, forked shaft ..... *P. plumosa* Ruppert, 1970
4b Feathered or curved tines; each tine arises independently from the scale base 5

5a Feathered tines ..... *P. faroensis* Clausen, 2004
5b Curved tines ..... *P. triancra* Hummon, 2008

6a Cuticular armature of tetrancres 7
6b Cuticular armature of pentancres 13

7a Five dorsal papillae (1+3+1) on the prebuccal apparatus 8
7b Seven dorsal papillae (2+3+2) on the prebuccal apparatus 10

8a Four TbA per side; seven pairs of cirrata tubes; no TbV ..... *P. mandela* Todaro, Perissinotto & Bownes, 2015
8b Bare area on the dorsal side present 9

9a Bare triangular area behind the preoral palps, TbV present as paired feet (four tubes per side) ..... *P. longifurca* Chang & Lee, 2002
9b Bare small area behind the preoral palps, Two TbA per side; one pair of cirrata tubes; three TbV per side ..... *P. indica* Rao, 1970

10a Caudal (copulatory) organ is tube-like in shape ..... *P. koreana* Chang & Lee, 2002
10b Caudal (copulatory) organ is pyriform in shape 11

11a Bare triangular area behind the preoral palps, posterior to the prebuccal apparatus ..... *P. roscovita* Swedmark, 1956
11b Bare area on the dorsal side absent 12

12a TbL, three pairs; body short (about 200 µm in length) ..... *P. malayica* Renaud-Mornant, 1967
12b TbL, eight pairs; body elongate (about 500 µm in length) ..... *P. andamanica* Rao, 1993

13a Five dorsal papillae present 14
13b Seven dorsal papillae present three TbA per side; pedicles of five tubes (1:3:1) each; footlike TbV present (four tubes per side) ..... *P. cataphracta* Ruppert, 1970

14a Four TbA; single dorsal tube protruding from base of preoral palps present ..... *P. etrusca* Hummon, Todaro & Tongiorgi, 1993
14b Two TbA; dorsal tube absent 15

15a Adhesive tubes along the pharyngeal region absent ... *P. cheraensis* Priyalakshmi, Menon & Todaro, 2007
15b Adhesive tubes along the pharyngeal region present 16

16a Single pair of adhesive tubes along the pharyngeal region; dorsal cuticular covering complete ... *Pseudostomella* sp.1 [Valbonesi & Luporini, 1984]
16b Two pairs of adhesive tubes along the pharyngeal region; presence of a bare area on the dorsal side arranged in "T"-shape, posterior to the prebuccal apparatus 17

17a Arrangement of the dorsal papillae(1+3+1); large and strong pentancres with central tine larger than the surrounding tines ..... *P. squamalongispinosa* Araújo, Balsamo & Garraffoni, 2014
17b Arrangement of the dorsal papillae (2+1+2); small sized pentancres with delicate, curved grasping tines of the same size ..... *P. dolichopoda* Todaro, 2012

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